REMARKS

Claims 1, 10, and 14-23 are canceled with specific reservation to pursue these claims in a divisional patent application or other patent application. Claim 24 is added. After entry of this amendment, claims 2-9, 11-13, and 24 will be pending. Claims 2, 3, 5, 9, 11, and 13 are amended to change dependency from canceled claim 1 to previously presented claim 8 or to new claim 24. No new matter is added by these amendments. No new matter is added by new claim 24. The Applicant sincerely thanks the Examiner for acknowledging that WO 00/39657 by Greenberg et al. does not qualify as prior art under 35 U.S.C. § 102(b).

Rejections under 35 U.S.C. §103(a)

Claim 8 stands rejected as being unpatentable over U.S. Patent No. 5,523,794 by Mankovitz et al. (hereinafter "Mankovitz"). The Applicant respectfully submits that claim 8 defines at least the following advantageous distinctive features that distinguish over and avoid Mankovitz:

> "a receiver configured to receive an electronic wireless transmission containing coupon information,"
>
> "a configurable portable electronic communication device," and
>
> "a memory containing a computer-readable program for generating a scannable coupon on the electronic display of the configurable portable electronic communication device from the coupon information and including instructions for converting the scannable coupon from a first scannable barcode format to a second scannable barcode format."

A first issue is whether Mankovitz discloses a receiver configured to receive an electronic wireless transmission containing coupon information. In order to establish a *prima facie* case of obviousness, Mankovitz must teach or suggest a receiver configured to receive an electronic wireless transmission. Mankovitz discloses an IR port (Fig. 2, ref. num. 16) for receiving data. The Examiner states that the IR receiver port of Mankovitz is taken to provide such a feature. The Applicant traverses the Examiner's position and urges that an IR port is not a receiver configured to receive an electronic wireless transmission. Rather, the IR port is for receiving an optical transmission (see, *e.g.*, Exhibit A, Figure 1, "Optical Transceiver").

Exhibit A, entitled *Wireless Communication Using the IrDA® Standard Protocol*,

paragraph 1, line 1 states that "[t]he two most popular mediums in the wireless arena are infrared (IR) and Radio Frequency (RF)." The art distinguishes between IR and electronic wireless (*e.g.* RF or microwave) techniques. Exhibit A states that IR technologies are better suited for short-range, point-to-point infrared communication channels. (see also, Exhibit B, *Introduction to IrDA*, page 2, stating that "IrDA devices conforming to standards IrDA 1.0 and 1.1 work over distances up to 1.0 m", with suitably low ambient illumination and suitable alignment). Portable electronic communication devices, such as cell phones, pagers, or PDAs (see, *Written Description*, page 4, line 14) having a receiver configured to receive electronic wireless transmissions can operate over much greater distances, and do not have to be precisely aligned with the transmitter.

The IR detector of Mankovitz is recognized in the art of wireless transmission to be an optical receiver, rather than a receiver configured to receive an electronic wireless transmission. The IR detector of Mankovitz does not operate in the same fashion or provide the same utility as the receiver of claim 8. In particular, the IR detector appears to be limited to short range use even when aligned to the transmitter, whereas a receiver according to claim 8 allows a much wider range of use. Therefore, claim 8 is not obvious in light of Mankovitz.

A second issue is whether Mankovitz discloses a configurable portable electronic communication device. In order to establish a *prima facie* case of obviousness, Mankovitz must teach or suggest a receiver configured to receive an electronic wireless transmission. The standard is not whether the Examiner thinks that the electronic coupon of Mankovitz is a configurable portable electronic device, but whether one of ordinary skill in the art would. Claim 8 recites a configurable portable electronic communication device in the body, as well as in the preamble, of claim 8; therefore, this limitation must be considered. The electronic coupon disclosed in Mankovitz is a specialized article, namely a portable data coupon, and is not a configurable portable electronic communication device as recited in claim and as discussed in the *Written Description* on page 4, lines 14-23. In light of the language of claim 8 and the definition provided in the *Written Description*, Mankovitz does not disclose the recited configurable portable electronic communication device and therefore claim 8 is not obvious in light of Mankovitz.

A third issue is whether Mankovitz discloses a memory containing a computer-readable program for generating a scannable coupon on the electronic display of the configurable portable electronic communication device from the coupon information and including instructions for

converting the scannable coupon from a first scannable barcode format to a second scannable barcode format. In order to establish a *prima facie* case of obviousness, Mankovitz must teach or suggest a memory containing a computer-readable program for generating a scannable coupon on the electronic display of the configurable portable electronic communication device from the coupon information and including instructions for converting the scannable coupon from a first scannable barcode format to a second scannable barcode format. It is the Examiner's burden to satisfy this condition by a preponderance of the evidence. The Examiner asserts that it would have been obvious to one of ordinary skill at the time of the invention to have provided the ability for the device of Mankovitz to convert the coupon data between several human-readable languages (English, Spanish, etc.) as well as several machine-readable barcode symbologies/languages/formats (UPC, UCC/EAN-128, etc.) so that different human operators and different POS scanners requiring various barcode formats can process the coupons for added flexibility and universality.

The Examiner does not indicate any part of the disclosure of Mankovitz to support his position and is in error. The Applicant traverses the Examiner's finding because Mankovitz does not teach or suggest converting from one barcode format to another, or even from converting from one language to another. Mankovitz states that "[d]uring the vertical blanking intervals of a television commercial, information associated with the telephone number, address or selection information <u>for local dealers</u> of the product or service are transmitted" (Col. 5, lines 29-33)(emphasis added). The electronic coupon device of Mankovitz is intended for local use. Mankovitz further states that "a standard UPC bar code format is . . . presented on the display." (Col. 5, lines 50-51). Mankovitz specifically teaches that a "standard UPC bar code format" is used. There is no disclosure or suggestion to modify the electronic coupon of Mankovitz to include a memory containing a computer-readable program for generating a scannable coupon on the electronic display of the configurable portable electronic communication device from the coupon information and including instructions for converting the scannable coupon from a first scannable barcode format to a second scannable barcode format. Furthermore, the teaching of Mankovitz that the coupon information is for local dealers teaches away from the universality urged by the Examiner as motivation for modification of Mankovitz's electronic coupon.

The mere fact that a device might have been modified in a certain manner does not render such modification obvious. The only suggestion to convert from one barcode format to another appears in the Applicant's teachings. The desirability for the modification asserted by the

Examiner echoes the Applicant's wording on page 9, lines 10-14 of the *Written Description*. It is impermissible to use the disclosure of the claimed invention as instructions to modify the prior art so that the claimed invention is rendered obvious. One cannot use hindsight reconstruction to deprecate the claimed invention. Therefore, the Examiner has not established a *prima facie* case of obviousness.

The Examiner asserted essentially the same findings in the final Office action mailed 08/25/2003. An Amendment After Final Rejection Under 37 C.F.R. § 1.116 ("Amendment After Final Rejection") was submitted on January 20, 2004 in response to the final Office action, traversing the Examiner's position in the last paragraph of page 9 of the Amendment After Final Rejection. The Amendment After Final Rejection was not entered at that time. On 02/24/2004, a Request for Continued Examination ("RCE") was filed requesting entry of the Amendment After Final Rejection.

In the Office action mailed 03/18/2004, which was the Office action following the Amendment After Final Rejection entered with the RCE, the Examiner took Official Notice that it is well known to provide computer devices with ability to convert data into different formats, and that it would have been obvious to have provided the ability for the device of Mankovitz to convert the coupon data into several machine-readable barcode symbologies. In his reply (Response to Office Action, mailed June 18, 2004), the Applicant respectfully requested additional proof from the Examiner or an affidavit under 37 C.F.R. §1.104(d)(2) on this point. Therefore, the Applicant believes that the Examiner's position on this issue was traversed in a timely and adequate manner.

The Examiner has not provided any citation to authority or affidavit supporting his position on this issue. The Examiner's line of reasoning is unsupported by any documentary evidence. This rejection appears to be based on the Examiner's personal knowledge and the Applicant's teachings. Section 2144.03 of the MPEP indicates that Official Notice unsupported by documentary evidence is only appropriate for facts that are capable of such instant and unquestionable demonstration as to defy dispute. The Applicant has defied the Examiner's position with argument and evidence comparing the Examiner's language to the as-filed application; hence, unsupported Official Notice is improper. The Applicant respectfully requests additional proof from the Examiner, an affidavit in accordance with 37 C.F.R. §1.104(d)(2), or withdrawal of this rejection.

Claim 8 alternatively stands rejected as being unpatentable over Mankovitz in view of

U.S. Patent No. 5,221,838 by Gutman et al. (hereinafter "Gutman"). The Examiner cites Gutman for teaching a portable electronic wallet that stores coupon data. The undersigned respectfully traverses the Examiner's position. The undersigned cannot find "coupon" or "coupon data" anywhere within the text of Gutman. If the Examiner finds such reference, the undersigned respectfully requests a specific citation as to where this material is found so that the Applicant may appropriately respond. If the Examiner cannot find such reference, the undersigned respectfully requests reconsideration and withdrawal of this rejection.

The Examiner also cites Gutman for disclosing a plurality of barcode format/symbology standards, and that several different bar code formats can be supported by the device. The Examiner asserts that it would have been obvious to have provided programming to convert between various formats of displayed bar-coded coupons. The Applicant respectfully traverses the Examiner's position.

A first issue is whether Gutman discloses a memory containing a computer-readable program for generating a scannable coupon on the electronic display of the configurable portable electronic communication device from the coupon information and including instructions for converting the scannable coupon from a first scannable barcode format to a second scannable barcode format. In order to establish a *prima facie* case of obviousness, Gutman must teach or suggest a memory containing a computer-readable program for generating a scannable coupon on the electronic display of the configurable portable electronic communication device from the coupon information and including instructions for converting the scannable coupon from a first scannable barcode format to a second scannable barcode format. It is the Examiner's burden to satisfy this condition by a preponderance of the evidence.

Gutman states only that a number of bar coding standards may be supported by the electronic wallet. While the electronic wallet might be able to render one barcode in a first format and another barcode in a second format, there is no disclosure of the ability to convert from one barcode format to another according to instructions in a memory of the electronic wallet. There is certainly no disclosure or suggestion in Gutman to convert a scannable coupon from a first scannable barcode format to a second scannable barcode format, as recited in claim 8.

A second issue is whether Gutman provides motivation to combine its disclosure with the electronic coupon of Mankovitz to arrive at the invention of claim 8. The Examiner asserts that the urged motivation would arise so as to increase flexibility and universality of the device. The

Examiner does not indicate any part of the disclosure of Gutman to support his position. The Applicant traverses the Examiner's finding because Gutman does not teach or suggest converting from one barcode format to another and thus cannot provide the asserted motivation. Furthermore, Mankovitz states that "[d]uring the vertical blanking intervals of a television commercial, information associated with the telephone number, address or selection information for local dealers of the product or service are transmitted" (Col. 5, lines 29-33)(emphasis added). The electronic coupon device of Mankovitz is intended for local use, thus teaching away from the asserted motivation of universality.

Mankovitz further states that "a standard UPC bar code format is . . . presented on the display." (Col. 5, lines 50-51). Mankovitz specifically teaches that a "standard UPC bar code format" is used, also teaching away from the asserted combination. There is no disclosure or suggestion to combine the disclosure of Gutman with the disclosure of Mankovitz. Furthermore, even if these references were combined it would not result in the invention of claim 8 because there is no disclosure of a memory containing a computer-readable program for generating a scannable coupon on the electronic display of the configurable portable electronic communication device from the coupon information and including instructions for converting the scannable coupon from a first scannable barcode format to a second scannable barcode format in either reference.

Accordingly, the Applicant believes claim 8 and all claims that depend from claim 8 are allowable, and respectfully requests reconsideration of claim 8 and withdrawal of all rejections of claim 8.

Claim 13 stands rejected as being unpatentable over Mankovitz. The Applicant respectfully submits that claim 13 defines at least the following advantageous distinctive features that distinguish over and avoid Mankovitz:

> "a persistent dot-matrix liquid crystal display having a minimum nominal dimension of less than or equal to about 13 mils and an inter-pixel spacing of less than or equal to about 1.3 mils coupled to the processor"

A first issue is whether one of skill in the art would have been motivated to modify the electronic coupon of Mankovitz to provide a persistent dot-matrix liquid crystal display having a minimum nominal dimension of less than or equal to about 13 mils and an inter-pixel spacing of

less than or equal to about 1.3 mils coupled to the processor. A particular parameter must first be recognized as a result - effective variable before the determination of the optimum or workable ranges of said variable might be characterized as routine experimentation. The Examiner states that it would have been obvious for one of skill in the art to routinely experiment with display characteristics so that the barcodes were displayed with sufficient clarity so that they can be successfully scanned at the POS. However, the prior art does not teach or suggest providing a persistent dot-matrix liquid crystal display having a minimum nominal dimension of less than or equal to about 13 mils and an inter-pixel spacing of less than or equal to about 1.3 mils. The Applicant emphasizes that desired characteristics of a display intended for displaying a scannable barcode are often different than those intended for visual viewing (see, *Written Description*, page 6, lines 1-30, more particularly lines 17-23). For example, the Applicant teaches that a persistent pixel, *i.e.* a pixel that retains its darkened state until the next strobe (*Written Description*, page 6, lines 26-27), is desirable to avoid scanning errors. No recognition of minimum pixel dimension, inter-pixel spacing, or persistence affecting first scan error rate is present in the cited art. Therefore, it would not have been routine for one of skill in the art to experiment with these characteristics to arrive at claim 13 and claim 13 is allowable.

A second issue involves the Official Notice taken regarding the knowledge of how to provide <u>a quality electronic display</u> (emphasis added). The Examiner states that the Applicant's argument appears to only challenge the conclusion that it would have been obvious to have applied such technology to a barcode display. The Applicant traverses and respectfully directs the Examiner's attention to page 3, second line, of the Office action mailed on 03/18/2004, wherein the Examiner takes Official Notice that it is well known that the quality of a barcode output is <u>related to the success in registering an error-free scan</u> (emphasis added). On page 9 of his response to that Office action (Response to Office Action, mailed June 18, 2004) the Applicant respectfully requested additional proof from the Examiner or an affidavit under 37 C.F.R. §1.104(d)(2) in light of the specialized and relatively esoteric technology involved with scanning barcodes from electronic displays, that such Notice be supported by citation to reference work recognized in the pertinent art so that the Applicant is given the opportunity, in the Patent Office, to challenge the correctness of the assertion or the notoriety or repute of the cited reference. The Applicant believes that the Examiner's Official Notice that it is well known that the quality of a barcode output is <u>related to the success in registering an error-free scan</u> was traversed in a timely and adequate manner. The Applicant again respectfully requests additional

proof from the Examiner or an affidavit in accordance with 37 C.F.R. §1.104(d)(2) and with MPEP §2144.03.

Furthermore, merely experimenting with display characteristics to obtain an electronic display that could be scanned adds nothing more than is disclosed in Mankovitz, which is addressed above in support of claim 1. In particular, there is no convincing line of reasoning as to why routine experimentation as urged by the examiner would result in the specific elements of claim 13, particularly since the problem of first scan errors is recognized only by the Applicant. One of ordinary skill would not have been motivated to optimize a parameter to solve the problem of first scan errors if he did not recognize the parameter as an operative variable affecting first scan error rate.

<u>New Claim 24</u>

New claim 24 recites means for improving the first scan rate of the scannable coupon from the electronic display of the configurable portable electronic communication device. No prior art of record recognizes the problem of first scan errors arising when bar codes are attempted to be scanned from electronic displays. The Applicant teaches that the display characteristics desirable for a visual display can be contrary to those desirable for a scannable display. Merely having a display that is operatively scanned does not disclose or suggest the recited means of claim 24. If a merely operative device could be considered to have improved performance, then no improvements to merely operative devices would ever be patentable. However, this position is inconsistent with long-standing law and practice. Even if improving the first scan rate was recognized as being desirable, no teaching or suggestion is provided in the cited art as to <u>how</u> to improve the first scan rate of a barcode displayed on an electronic display. It is the Applicant who recognized the problems arising from scanning barcodes from electronic displays, and who teaches specific solutions for improving the first scan rate of barcodes on an electronic display. Therefore, the Applicant believes claim 24 is further patentable.

CONCLUSION

In view of the foregoing, the Applicant believes all claims pending in this Application are in condition for allowance, and that the Applicant is entitled to the claims in accordance with Title 35 of the United States Code, and Art.1, §8, cl.8 of the Constitution of the United States.

The Applicant respectfully requests reconsideration of all pending claims, the withdrawal of all rejections, and the issuance of a formal Notice of Allowance at an early date.

Should the Examiner consider necessary or desirable any formal changes anywhere in the specification, claims and/or drawings, then it is respectfully asked that such changes be made by Examiner's Amendment, if the Examiner feels this would facilitate passage of the case to issuance. If the Examiner believes this amendment does not put all pending claims in condition for allowance, the undersigned invites the Examiner to telephone the undersigned at (707) 591-0789.

Respectfully Submitted

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Wireless Communication Using the IrDA® Standard Protocol

By Bonnie C. Baker, Microchip Technology Inc.

ANALOG DESIGN NOTE ADN006

The two most popular mediums in the wireless arena are Infrared (IR) and Radio Frequency (RF). When asked to develop a wireless system, you may be concerned about cost, ease-of-design, and distance requirements. IR technologies are better suited for short distance, low-to-medium data throughput, wireless communication channels. Two common types of IR technologies are currently in use. These are the TV Remote (TVR) and the IrDA (Infrared Data Association) standard protocol.

The lowest cost wireless connection technology is TVR. The trade-off with this technology is between distance and bit-rate. Usually this interface is also unidirectional. If a bidirectional, higher data bandwidth is required in your application, you may opt to design an IrDA system. This infrared communication standard has been defined by the IrDA industry-based group(1). This group has developed communication standards that are well suited for low-cost, short-range, point-to-point infrared channels. These types of channels operate over a wide range of speeds under a cross-platform environment. IrDA standards have been used to install over 300 million low-cost, short-range communication systems in laptops, printers, handheld PCs, and PDAs, to name a few.

An example of an IrDA standard embedded system is shown in Figure 1. In this system, the Primary device (PDA) searches for other IrDA standard devices. The Secondary device (Host Controller and MCP2150) will respond to queries from the Primary device.

The host controller controls the MCP2150 by sending and receiving data through its UART interface port. The MCP2150, which is positioned between the host controller UART device and infrared optical transceiver, decodes and encodes the signal.

The MCP2150 has two independent baud rates. One of the baud rates is for communication with the Primary device (PDA). The Primary device negotiates this baud rate with the MCP2150, as defined in the IrDA standard. The second baud rate is set with the two hardware pins, BAUD1 and BAUD0. This second baud rate is for communication with the host controller.

The IrDA standard is a network protocol and follows a layered approach in its definition. A model of the IrDA protocol stack is shown in Figure 2. These protocols deal with a manageable set of responsibilities and also supply needed capabilities to the layers above and below.

The MCP2150 is an IrDA Standard Protocol Stack Controller, which provides support for the IrDA standard protocol "stack" plus bit encoding/decoding.

One of the functions of the MCP2150 is to encode and decode the asynchronous serial data stream.

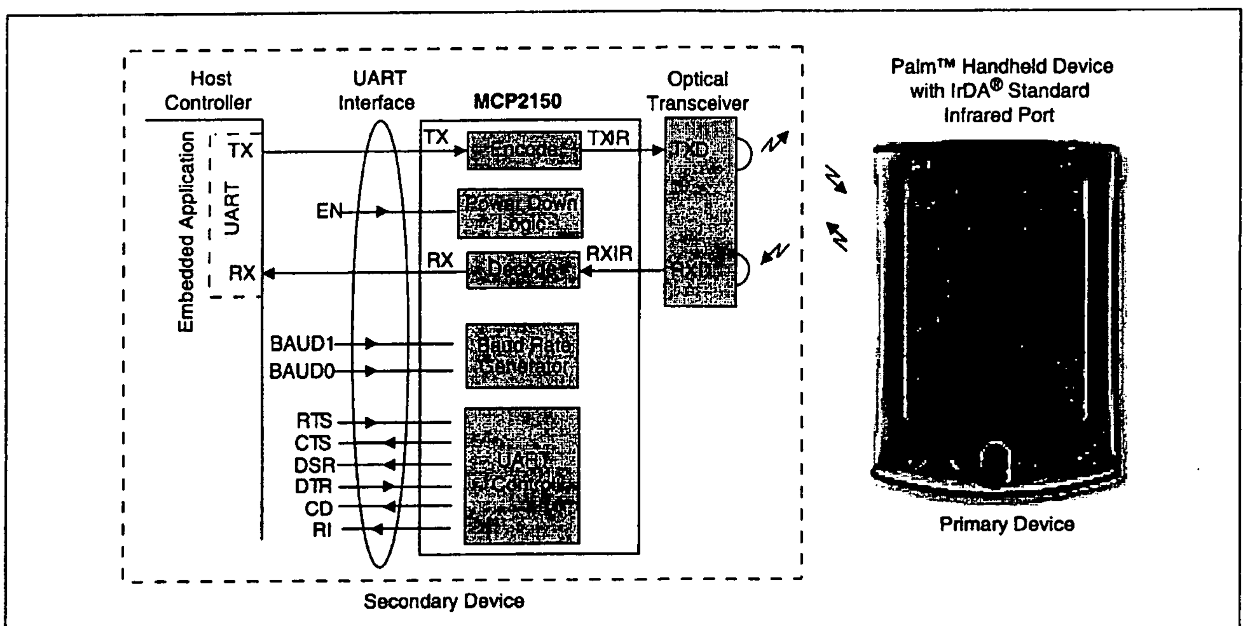

Figure 1. *The Primary Device (PDA) sends data through the infrared interface to the MCP2150. The MCP2150 then decodes this data into the UART standard. After translation, the data is sent to the Host Controller through the UART interface. The Host Controller can also send data to the MCP2150 where the data is encoded and made ready for transmission to the Primary device.*

<table>
<tr><td>IrTRAN-P</td><td>IrObex</td><td>IrLAN</td><td>IrCOMM [1]</td><td>IrMC</td></tr>
<tr><td>LM-IAS</td><td colspan="4">Tiny Transport Protocol (Tiny TP)</td></tr>
<tr><td colspan="5">IR Link Management - Mux (IrLMP)</td></tr>
<tr><td colspan="5">IR Link Access - Mux (IrLAP)</td></tr>
<tr><td colspan="2">Asynchronous Serial IR [2, 3] (SIR)
(9600 - 115200 Baud)</td><td colspan="2">Synchronous Serial
IR (1.15 MBaud)</td><td>Synchronous Fast
IR (FIR)
(4 MBaud)</td></tr>
</table>

Figure 2. *This IrDA protocol stack has been defined by the IrDA industry-based group. Within the protocol stack data communications, details, as well as the data structures, are defined.*

The encode/decode translation format is shown in Figures 3 and 4. Figure 3 shows how the received IR data from the PDA is decoded to UART-formatted data. Figure 4 demonstrates how data is taken from the Host Controller, into the MCP2150, and encoded in preparation of transmission to the PDA. The IrDA bit format is the NAND of the UART signal. The bits are inverted and high pulses are shortened in order to reduce the optics power consumption. The MCP2150 decodes the IR data, which is then handled by the protocol handler state machine. The protocol handler sends the appropriate data bytes to the Host Controller in UART-formatted serial data.

The MCP2150 replaces a wired serial connection with a wireless solution. The MCP2150 allows designers to add IrDA wireless connectivity to their embedded system designs easily and cost effectively. With this device, the host UART interface allows easy connections to PC serial ports. Another product available is the MCP2155, which is best suited for serial port interfaces (ie., modems). In all cases, these point-to-point systems connect to devices of "higher intelligence", such as PCs, PDAs, etc.. This minimizes the cost of MCP215X-type devices. The MCP215X can also serve as a primary device in these point-to-point applications. Both devices provide support for the IrDA standard protocol "stack" plus bit encoding and decoding capability.

Another product in this family from Microchip is the MCP2140, which is an IrDA standard protocol stack controller with a fixed baud communication rate of 9600. Adding IR connectivity to cost-sensitive, high volume, embedded applications was not really feasible prior to the introduction of the MCP215X and MCP2140 parts. These parts remove the requirement of the system designer needing to implement the complex IrDA stack. Finally, the MCP2120 is an infrared encoder/decoder chip.

Sending data using IR light requires some hardware and specialized communication protocols. These protocol and hardware requirements are described, in detail, in the IrDA standard specifications. The encoding/decoding functionality of the MCP2150 is designed to be compatible with the physical layer component of the IrDA standard. This part of the standard is often referred to as "IrPHY". Additionally, the MCP2150 handles the speciallized communication protocol, IrCOMM (9-wire "cooked" service class). A complete list of IrDA standard specifications is available on the IrDA website (www.irda.org).

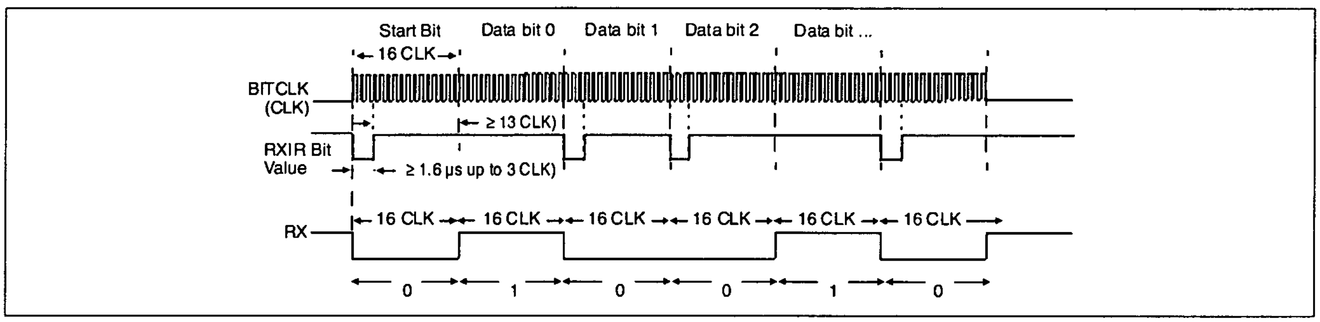

Figure 3. *Bit Encoding*

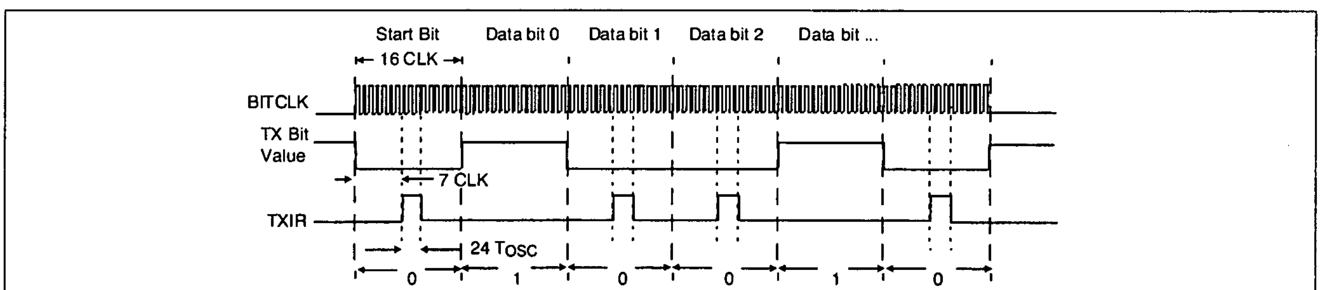

Figure 4. *Bit Encoding*

Recommend References:

[1] *www.irda.org - Trade Association for Defining Infrared Standards, IrDA System Protocol consortium web site.*
AN858 *- "Interfacing the MCP215X to a Host Controller", Palmer, Mark, Microchip Technology Inc.*

MICROCHIP

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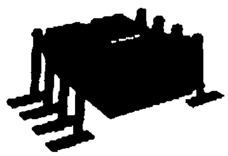
EXHIBIT B



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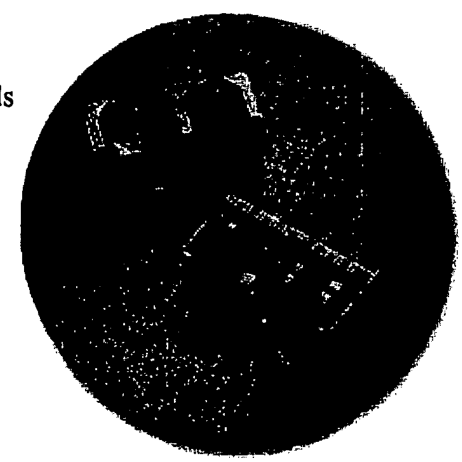
Introduction to IrDA

IrDA is a standard defined by the IrDA consortium (Infrared Data Association). It specifies a way to wirelessly transfer data via infrared radiation. The IrDA specifications include standards for both the physical devices and the protocols they use to communicate with each other. The IrDA standards have arised from the need to connect various mobile devices together. (Primary use for IrDA is to link notebooks or various personal communicators; however, even video cameras are sometimes equipped with an IrDA interface.)



IrDA devices communicate using infrared LED's. Wavelength used is 875 nm +- production tolerance (around 30 nm). Many CCD cameras are sensitive to this wawelength too. Receivers utilize PIN photodiodes in generation mode (incoming light "kicks out" electrons. Signal continues into a filter. Only allowed frequencies for a particular IrDA modulation can pass through.) There is a direct relationship between the energy of the incoming radiation, and the charge that the optics part of the receiver generates.

Range and speed of IrDA

IrDA devices conforming to standards IrDA 1.0 and 1.1 work over distances up to 1.0m with BER (**B**it **E**rror **R**atio - number of incorrectly transferred bits over number of correctly transferred bits) 10^{-9} and maximum level of surrounding illumination 10klux (daylight). Values are defined for a 15 degree deflection (off-alignment) of the receiver and the transmitter; output power for individual optical components is measured at up to 30 degrees. Directional transmitters (IR LEDs) for higher distances exist; however, they don't comply with the required 30 degree radiation angle.

Speeds for IrDA v. 1.0 range from 2400 to 115200 kbps. Pulse modulation with 3/16 of the length of the original duration of a bit is used. Data format is the same as for a serial port - asynchronously transmitted word, with a startbit at the beginning.

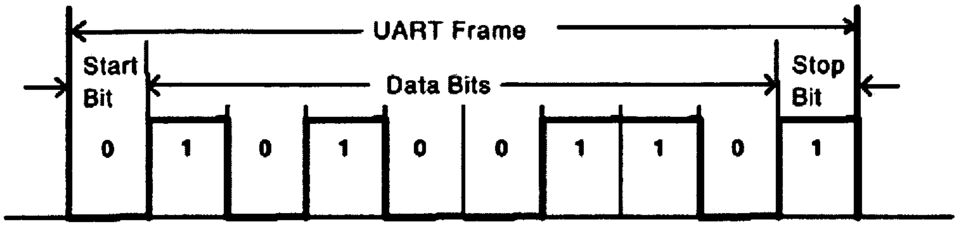


Figure 11a. UART Frame

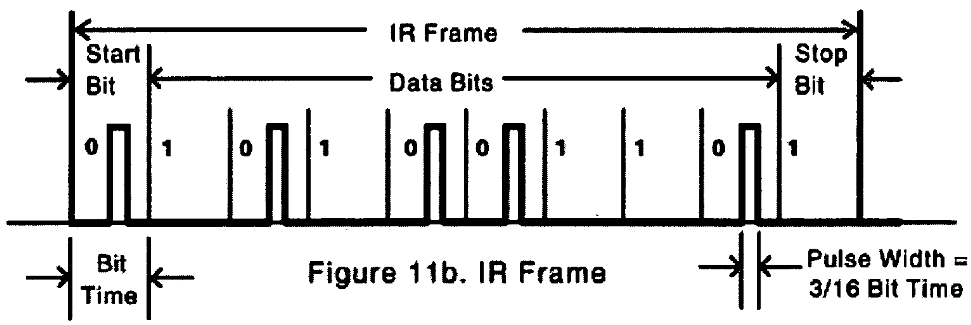
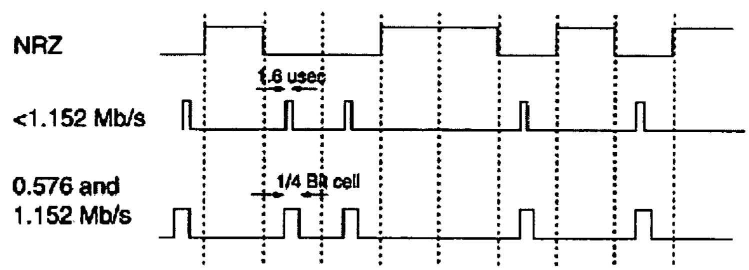


Figure 11b. IR Frame

Transmitter can use either 3/16 mark-to-space ratio for one bit, or a fixed length 1.63 us of each optical pulse, which would correspond to 115kbps. With fixed length and speed of 38400 bps, each bit would take 3 pulses.

In addition, IrDA v. 1.1 defines speeds 0.576 and 1.152 Mbps, with 1/4 mark-to-space ratio. At these speeds, the basic unit (packet) is transmitted synchronously, with a starting sequence at the beginning.

The NRZ signal in the figure is the original data signal without modulation.



A packet consists of two start words followed by target addres (IrDA devices are assigned numbers by the means of IrDA protocol, so they are able to unambiguously identify themselves), data, CRC-16 and a stop word. The whole packet (frame) including CRC-16 is generated by IrDA compatible chipset. Start and stop words cannot appear anywhere else in the data stream - start and stop words last 1.5times the bit duration (6 times longer flash than usual).

STA	STA	ADDR	DATA	16b FCS	STO

STA:	Beginning Flag, 01111110 binary
ADDR:	8 bit Address Field
DATA:	8 bit Control Field plus up to 2045 = (2048 - 3) bytes Information Field
FCS:	CCITT 16 bit CRC
STO:	Ending Flag, 01111110 binary

For 4Mbps speed, so-called 4PPM modulation with 1/4 mark-to-space ratio is used. Two bits are encoded in a pulse within one of the four possible positions in time. So, information is carried by the pulse position, instead of pulse existence as in previous modulations. For example, bits `00` would be transmitted as a sequence `1000` (flash-nothing-nothing-nothing), bits `01` would be `0100`, bits `11` would be send as `0001`.

Data Byte	Resulting DBPs	Resulting DD Stream (chips and symbols transmitted from left to right for LSB first reception)
X'1B'	00 01 10 11	[redacted]
[redacted]	[redacted]	0001
[redacted]	[redacted]	0010
[redacted]	[redacted]	0100
[redacted]	[redacted]	1000
[redacted]	[redacted]	0001 0010 0100 1000
X'0B'	00 00 10 11	0001 0010 1000 1000
X'A4'	10 10 01 00	1000 0100 0010 0010

First chip delivered to/received by physical layer.

Last chip delivered to/received by physical layer.

Main reason for the 4PPM modulation is the fact, that only half of the LED flashes are needed than in previous modulations; so, data can be transferred two times faster. Besides, it is easier for the receiver to maintain the level of surrounding illumination - with the 4PPM modulation, a constant number of pulses is received within a given time.
With bit speed of 4Mbps, the transmitter flashes at 2MHz rate. However, unlike 0.576 and 1.152 Mbps, 4Mbps packets use CRC-32 correction code. Most chipsets which can use this modulation can also generate CRC-32 by themselves, and check it when receiving - some chipsets (the ones I have studied) throw away incorrectly received frames.

Link layer frame			
A	C	Information	CRC32

PA	STA	DD ...	STO

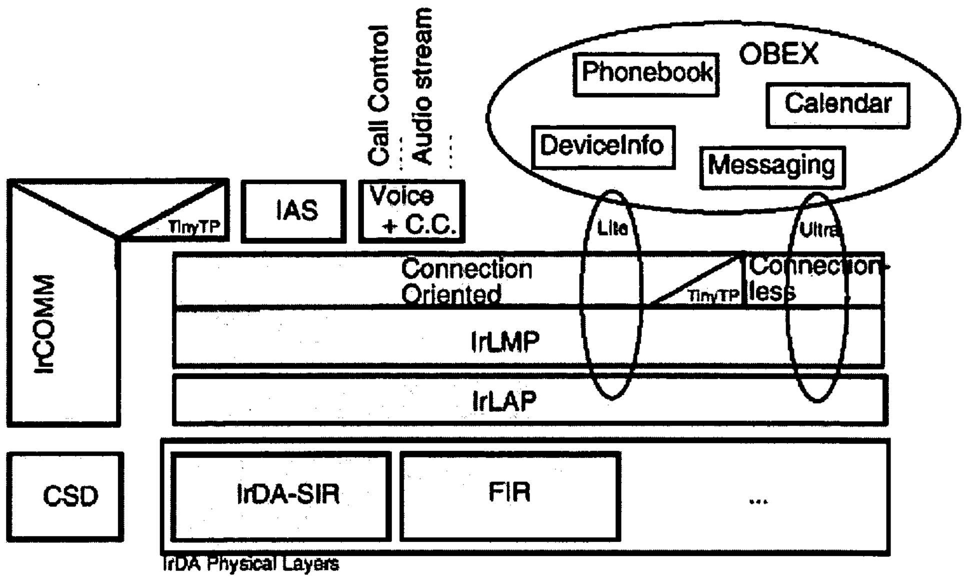
More, IrDA defines so-called low-power IrDA device, with range up to 20 cm and max. speed 115kbps (a.k.a. IrDA 1.0). Limiting factor for the range is the radiation intensity at the receiver in mW/cm^2. This value is higher for faster bit speeds, for slower bit speeds (long pulses) the possible range increases. (This is not explicitly mentioned in the IrDA standards, but it correlates to the amount of incoming radiation - receiver thinks that short low-energy pulses are noise. For its filter to let them through, they need to be either longer, or their energy must be higher.)

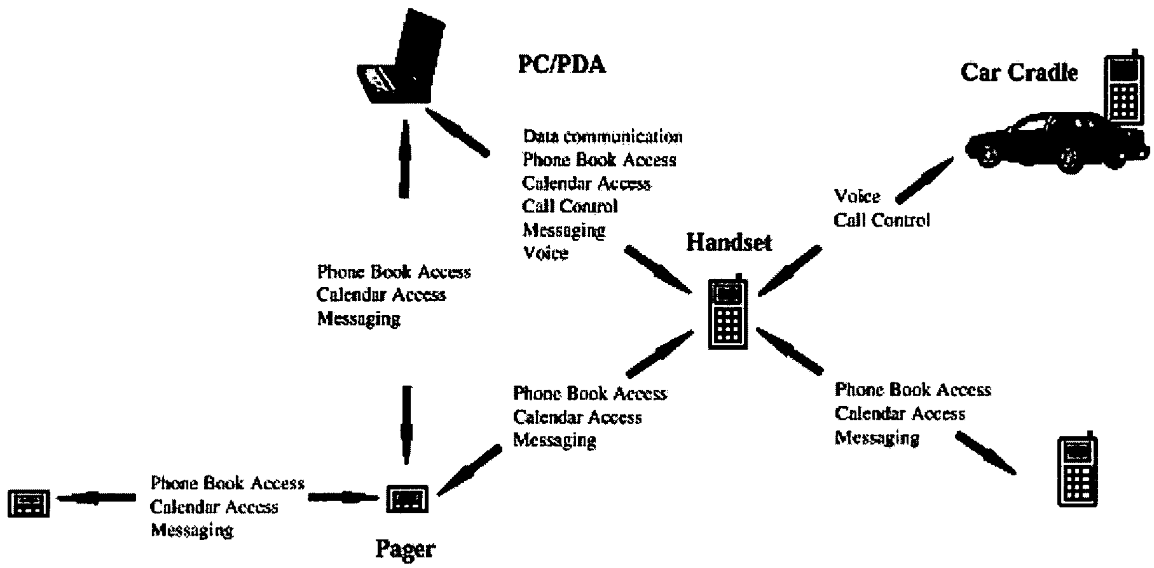
Why a pulse modulation is used?

The receiver needs a way to distinguish between the surrounding illumination, noise, and received signal. For this purpose, it is useful to use the highest possible output power: higher power -> higher current in the receiver -> better signal-to-noise ratio. However, IR-LED's can't transmit at full power continuously over 100% of time. So, a pulse width of only 3/16 or 1/4 (mark-to-space ratio) of the total time for one bit is used. Now, the power can be up to 4 or 5 times the possible maximum power for LED's shining continuously. In addition, the transmission path does not carry the dc component (since the receiver continuously adapts itself to the surrounding illumination, and detects changes only.), thus it is necessary to use pulse modulation. Integrated IrDA transceivers (combined transmitting IR-LED and the receiving PIN photodiode) do have filters that eliminate noise other than the IrDA frequency range 2400-115200 bps and 0.576-4Mbps (2M flashes/s).

Protocols used by IrDA devices

- **IrDA Infrared Link Access Protocol (IrLAP)**
  is a modification of the HDLC protocol reflecting the needs of IrDA communication. In general, it encapsulates the frames and makes sure the IrDA devices don't fight among themselves - in multi-device communication, there is only one primary device, others are secondary. Note that the communication is always half-duplex. Also, IrLAP describes how the devices establish connection, close it, and how are they going to be internally numbered. Connection starts at 9600 Bd; as soon as information about supported speeds is exchanged, logical channels (each controlled by a single primary device) are created.
- **IrDA Infrared Link Management Protocol (IrLMP)**
  Since configuration of IrDA devices changes (you turn on your IrDA camera and put it next to your notebook), every device lets the others know about itself via the IrLMP protocol, which runs above IrLAP (IrLAP is a link protocol; I would compare it to the IP protocol, although address resolution is different). IrLMP's goal is to detect presence of devices offering a service, to check data flow, and to act as a multiplexer for configurations with more devices with different capabilities involved (compare to sockets in TCP/IP communication). Then, applications use the IrLMP layer to ask if a required device is within range, etc. However, this layer does not define a reliable way to create a channel (like in TCP); this is defined by IrDA Transport Protocols (Tiny TP).
- **IrDA Transport Protocols (Tiny TP)**
  This layer manages virtual channels between devices, performs error corrections (lost packets, etc.), divides data into packets, and reassembles original data from packets. It is most similary to TCP.
- **IrDA Object Exchange Protocol (IrOBEX)**
  is a simple protocol, which defines PUT and GET commands, thus allowing binary data transfer between devices. It is built on top of TinyTP. The standard defines what a packet must contain in order for the devices to recognize each other and communicate.
- **Extensions to IrOBEX for Ir Mobile Communications**
  This extension of IrOBEX for mobile devices - handhelds, PDA, cellular phones - defines how to transfer informations pertaining to GSM network (address books, SMS, calendar, dialing control, digital voice transfer over IR, ...)





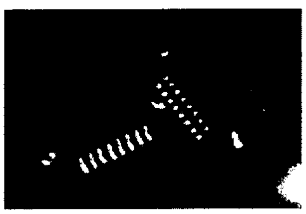
- **IrTran-P (Infrared Transfer Picture) Specification**
  This definition was made up by big companies manufacturing digital cameras and specifies how to transfer pictures over the infrared interface. It is built on top of TinyIP, too.

IrDA components

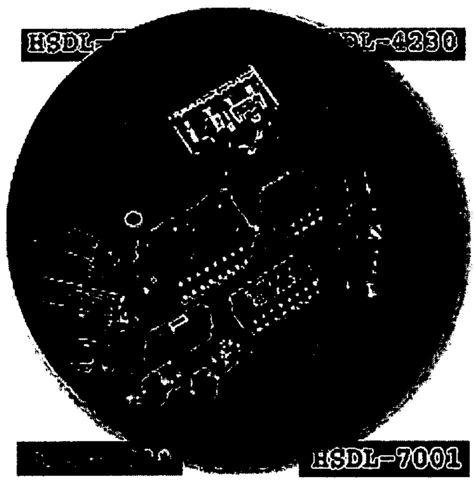
Here, I can describe my own experience with several components made by Hewlett Packard. They manufacture stand-alone IrDA transmitters (IR LED), receivers, as well as transceivers (a receiver with a transmitter in a single package). For speeds up to 115kbps (IrDA 1.0), HSDL-

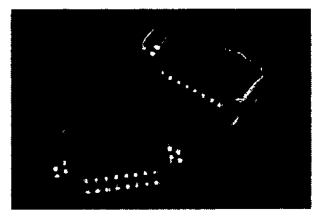
1000 transceiver is available. It works in half-duplex mode. It is very easy to use. Besides the transceiver itself, only several capacitors to filter the signal and to reduce noise are used. The capacitors need to be placed as close to the transceiver as possible, preferably within 0.7 cm (0.3 in). Since the HSDL-1000 is in a SMD package, it is a good idea to place it on a two-layer PCB, with ground copper area on the other side for shielding.
A faster version of the transceiver is labelled HSDL-1100. It supports FIR speeds (up to 4Mbit/s). However, I had problems with this one. In improper design, the FIR output easily becomes an oscillator. This part is also more sensitive to noise and unwanted feedbacks than the HSDL-1000 (FIR output only).

Other HP components available include IR LEDs HSDL-4230 and HSDL-4220. These LEDs withstand modulation speed up to 10Mbits, maximum current 0.5A (mark-to-space ratio 0.2) or 100mA (continuously). The only difference of the two versions in the HSDL-4200 family is their radiation angle (30 degrees for HSDL-4220, only 17 degrees for HSDL-4230).



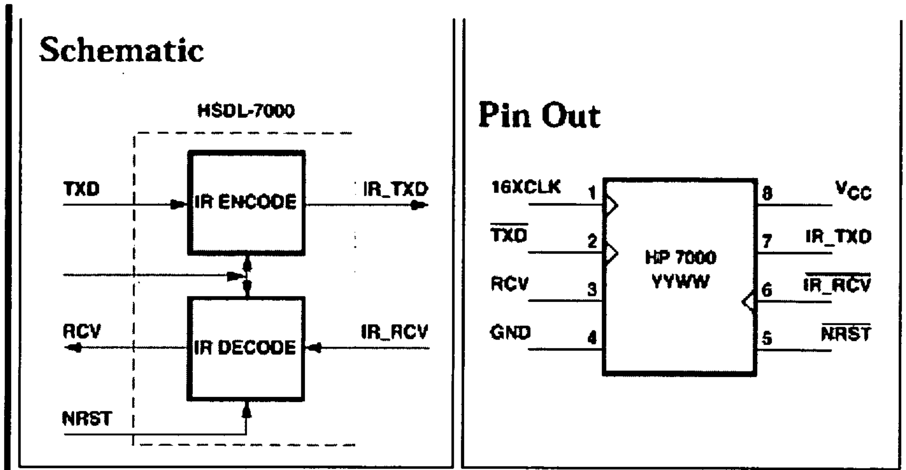
HSDL-1000





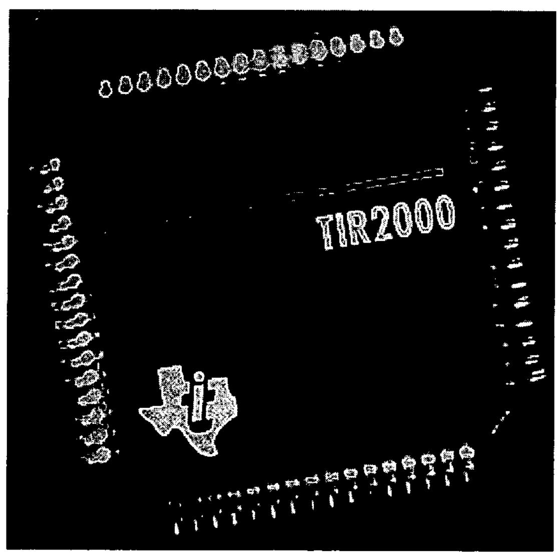
HSDL-1100

Also, Hewlett-Packard manufactures standalone PIN receivers as well as IrDA modulation encoders/decoders. Integrated encoder/decoder of IrDA 115kbps modulation can be ordered under part No. HSDL-7000. It is an integrated circuits with 8 pins. In addition to power, serial port transmit/receive, a 16-times the bit frequency oscillator needs to be connected to it (for 115kbps, required frequency is 115200*16=1.8432 MHz). I had a chance to try out encoder/decoder HSDL-7001; however, it offers only a few additional functions (e.g. integrated frequency divider, or a possibility to connect a passive XTAL directly to its inputs). In addition, the integrated frequency divider works for IR input only, not for the output.



Schematics of the 3/16 modulator HSDL-7000

Of course, Hewlett-Packard is not the only manufacturer of IrDA components. For example, Texas Instruments manufactures UART's labeled TIR1000 and TIR2000. The TIR2000 incorporates a driver for the 4Mbps modulation (uses DMA mode). National Semiconductors produce their own versions. And so on. In the Czech Republic, UARTs by TI and NS circuits are probably the most commmon ones.



Links to manufacturers of IrDA components

Here are links to WWW pages of different IrDA devices manufacturers.

IBM
Hewlett Packard

HP ir chip directory
HP ir center
Texas Instruments
National Semiconductor PC87109
Vishay-Telefunken (drive Temic) Nemecko
Vishay-Telefunken (drive Temic) USA
Linux support for IrDA
I don't have to mention IrDA protocol support at Micro$oft. However, here is a link to The Linux/IR Project, whose objective is to incorporate IrDA protocols into Linux kernel. Source codes are tested on development Linux kernels (2.1.xxx), (2.1.xxx)

Practical experiences

When playing with the IrDA data transfer, our goal was far beyond the 1 meter range specified by the IrDA standard. Using IR LED's with half the radiation angle (17 degrees, instead of 30), we could go up to 4 meters without additional optics at 115 kpbs bit rate. Beyond a certain distance, the receiver tends to loose individual pulses, or decrease their amplitude and duration (after all, it is an analog circuit although its output is supposed to be "digital"). For greater distances (our requirement was to transfer data over a 200m distance), additional optics is needed. We have found that, if speed is decreased 4 times, distance can be increased two times. This confirms the thesis about pulse detection via certain amount of energy passing through the filter in the receiver.

Since our goal was to connect two Linux boxes and run ppp protocol over a serial line, we have created additional logic (1 gate ;). It would continuously send pulses while DTR signal remained inactive, and thus signal a 'hang-up' to the other side. A side effect is that if the serial cable from the computer to the IrDA link is pulled out, the circuit starts sending pulses - as if the computer had hanged up via the DTR signal. This can be used in debugging process - finding signal. More, transmitter can be connected to the receiver on one side, creating a several hundred meters long loopback - ideal for checking connection quality in both directions, without the need to run there and back.

With the additional optics, we have found after some time that for distances less than about 80 meters (115 kBd speed), full-duplex mode cannot be used since the transmitted beam reflects back and creates echos. The same applies whenever there is a reflective object in the signal path - a window, for instance.

Alignment of the link is critical. The mount has to be very firm, and able to fine-point the components, so they are co-axial. Reasonable bit errors can be achieved if the link is aligned within about one meter (distance 200m - corresponds to approx. one half of a degree angle). Alignment is critical for the transmitter, not the receiver. Our best result was about 0.0006% faulty packets (MTU=296 bytes, ping packet length 64 bytes), in other words, about one packet out of 170000 packets is bad. The statistics for the other direction were about four times worse - bad alignment. Normal rain is obviously not an issue (it has been raining for two days already), problems arise with heavy rain or direct sunshine to the optics.

```
ppp0      Link encap:Point-to-Point Protocol

          inet addr:10.1.2.4  P-t-P:10.1.1.4  Mask:255.255.255.0
```

UP POINTOPOINT RUNNING MTU:296 Metric:1

RX packets:49724542 errors:233 dropped:233 overruns:0 frame:0

TX packets:49625500 errors:0 dropped:0 overruns:0 carrier:0 coll:0

This is our ppp line statistics, 115kbps, full duplex, rain, 200m

ppp0 Link encap:Point-to-Point Protocol

inet addr:10.1.2.4 P-t-P:10.1.1.4 Mask:255.255.255.0

UP POINTOPOINT RUNNING MTU:296 Metric:1

RX packets:25255596 errors:18 dropped:18 overruns:0 frame:0

TX packets:25276229 errors:0 dropped:0 overruns:0 carrier:0 coll:0

and this one with good weather and a different setting (again 200m)

Pictures in the text are from WWW pages of Hewlett Packard, Texas Instruments, and bitmap version of pdf documents by IrDA consortium.

For pricing information of IrDA components, please contact your local electronics components dealer.

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